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Influence of maternal feed rationing on metabolic and contractile properties of *Longissimus lumborum* muscle fibres in the rabbit offspring

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Abstract

Thirty hybrid female rabbits of 15 weeks of age were divided into three groups and fed for 8 weeks (until the first parturition) on one of the three following diets: "C diet" (DE = 11.71 MJ/kg DM) fed ad libitum; "R diet" was the C diet fed at 80% of ad libitum, "F diet" rich in fibre (24.6% vs 18.7% for C diet; DE = 9.77 MJ/kg DM) fed ad libitum. Afterwards, all the does received the C diet ad libitum. One pup per litter was slaughtered at birth, one at 35 d (weaning) and one at 81 d of age. At the second parturition, another pup per litter was slaughtered at birth. Ten minutes *post mortem* the *Longissimus lumborum* (LL) muscle was sampled and the mean cross-sectional area, compactness index (CI) and sphericity of the fibres of the new-born rabbits were determined; on rabbits of 35 and 81 d of age the fibre type distribution (βR, αR or αW) was also measured. The two maternal rationed-diets significantly increased the CI of LL fibres of new-born rabbits of the first kindling, compared to the C diet. On weaning rabbits the greatest effect of maternal feed rationing was observed on the percentage of αW fibres ($P < 0.01$), which was the highest for the F diet (85.2%), intermediate for the C diet (78.0%) and the lowest for the R diet (71.8%). At 81 d of age, no effect of maternal dietary treatment was found on offspring.

Keywords: Rabbit; Doe; Feed rationing; Muscle; Fibre type

1. Introduction

The young nulliparous rabbit does fed ad libitum with diets of high energy level often show parturition problems, with the subsequent reduction of the number of new-born rabbits, linked to excessive fatness (Fortun-Lamothe & Lebas, 1996). The administration of energy-rich diets during lactation increased the milk output, but was not able to reduce the energy *deficit* normally induced by pregnancy, or by the simultaneous lactation and pregnancy, because the doe's stomach volumetric capacity is limited and her intake of food cannot meet the requirements. In primiparous does, which are still growing, the stomach capacity is not enough to cover the doe's requirements so, if pregnancy and lactation overlaps, the energy *deficit* increases strongly.

In order to reduce the excessive fatness of young rabbit does, restricted feeding is frequently applied. A dietary energy restriction balanced with an increase of fibre content administered to young female rabbits until the first parturition, could increase the stomach and caecum volumetric capacity and, consequently, increase the energy intake during the following lactation, reducing the negative energy balance. Research on the effect of restricted feeding on reproductive performance of rabbit does is widely performed

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(Fortun-Lamothe & Lebas, 1996; Fortun-Lamothe & Prunier, 1999; Rommers, Meijerhof, Noordhuizen, & Kemp, 2001; Xiccato, Bernardini, Castellini, Dalle Zotte, & Queaque, 1999; Xiccato, Parigi Bini, Dalle Zotte, Carazzolo, & Cossu, 1995). Research on the effect of maternal restricted feeding on the offspring's productive performance are scarce and limited to the birth-weaning period (Dalle Zotte, Chiericato, Rizzi, & Zakaria, 2001; Pascual, Tolosa, Cervera, Blas, & Fernàndez-Carmona, 1999; Szendrö, 2000). The consequences of maternal feed restriction on the metabolic and contractile properties of muscle fibres on rabbit offspring have not been studied.

Muscle fibre characteristics are thought to be important factors influencing meat quality; however, a direct effect of fibre type on meat quality remains to be established (Lefaucheur & Gerrard, 1998).

In rabbits, when the dietary energy content was reduced during the post-weaning period, a reduction was observed in the cross-sectional area (CSA) of all types of muscle fibres, together with a reduction in the growth rate, slaughter yield and carcass fatness (Dalle Zotte & Ouhayoun, 1998). The consequences of maternal feed restriction on the carcass and meat quality of rabbit offspring are under investigation. It could be hypothesised that if an effect of maternal feed restriction on fibre characteristics is manifested in the rabbit offspring, some meat quality traits could be negatively modified also.

The aim of the present work was to evaluate the effects of a moderate feeding restriction of nulliparous does, applied until first parturition, on muscle fibres properties of rabbit offspring belonging to the first and the second kindling.

2. Materials and methods

2.1. Animals, housing and experimental diets

One hundred and forty hybrid female rabbits were individually housed in commercial cages at the age of 15 weeks. After an adaptation period of 4 d the young females were divided at random into three groups and fed on one of the three following diets: the "C" diet for young females (DE = 11.71 MJ/kg DM) fed on ad libitum; the "R" diet, was diet C fed at 80% of ad libitum, the "F" diet rich in fibre (24.6% vs 18.7% for the C diet; DE = 9.77 MJ/kg DM) was also fed ad libitum. The young does were artificially inseminated at 19 weeks. The three diets were administered until the first parturition, afterwards all the does received the C diet ad libitum. From each experimental group, 10 does were selected at random and three pups of their first offspring were chosen. The weight of litters at birth, dead-born included, and the alive-litter size at birth did not differ significantly among the experimental groups ($P > 0.05$).

The second insemination occurred nine days after parturition and all the lactating does were concurrently pregnant. At the second parturition another pup per doe was identified in the same way. At each birth, the litter size was equalised to eight by cross-fostering.

2.2. Slaughtering and sampling

The three pups identified per doe belonging to the first offspring were slaughtered at birth, at 35 d of age (weaning) and at 81 d of age, respectively. After the slaughter at birth, the litter size per doe was seven until weaning. The pup identified at the second parturition was slaughtered at birth. Ten minutes *post mortem* the *Longissimus lumborum* (LL) muscle was sampled between the third and the seventh lumbar vertebra and then underwent the histochemical treatment (freezing in isopentane cooled by liquid nitrogen). Samples were then stored at −80 °C until analysis.

2.3. Histochemical analysis of the Longissimus lumborum muscle

Six serial cross-sections (10 μm thick) from each LL sample, belonging to rabbits of 1, 35 and 81 d of age were obtained with a cryostat at −20 °C. One was stained with azorubine (reference staining); four were processed according to the myofibrillar ATPase after successive preincubations in acid and alkaline buffers (Guth & Samaha, 1970) and one was stained for succinic dehydrogenase (SDH) activity (Nachlas, Tsou, De Souza, Chang, & Seligman, 1957). For the acid preincubation, three pH values ranging from 4.15 to 4.30, were tested on 3 sections and the one that gave the best fibre typing contrast was retained. The fourth one was used for alkaline pre-incubation (pH 10.4). Myofibrillar ATPase and SDH stain intensities were estimated for each individual cell and used for fibre classification according to Ashmore and Doerr (1971) as βR, αR or αW by combination of metabolic (R, red or W, white) and contractile (α, fast-twitch or β, slow-twitch) characteristics. Percentage, mean CSA (μm^2), compactness index (CI) (perimeter^2/area) and sphericity (SPH) (d/D = smallest diameter/biggest diameter) of each fibre type were determined on approximately 300 fibres in three random fields for each muscle with a computerised image analysis system (Buche, 1990). Fibres of the new-born rabbit's LL muscle were all identified as αR type, so, only histomorphological characteristics were determined on azorubine-stained fibres. The software *Racine* was used on a Unix workstation equipped with a graphics card (Imaging Technology FG100).

2.4. Statistical analysis

Variance analysis was performed using the GLM procedure of the SAS program (SAS Institute, 1990), by including diet as fixed effect.